DEDICATION

To my family

TABLE OF CONTENTS

CHAPTER I. LITERATURE REVIEW	1
INTRODUCTION	xiv
Acknowledgements	ix
ist of Tables ist of Figures cknowledgements bstract rabic Abstract NTRODUCTION HAPTER I LITERATURE REVIEW	

1.1. Rotifers morphology, biology and life history	1
1.2. Rotifers species differences.	2
1.3. Rotifers reproduction.	5
1.4. Water quality and culture conditions of rotifers	6
1.4.1. Temperature	6
1.4.2. Salinity.	7
1.4.3. Dissolved oxygen	10
1.4.4. pH	11
1.4.5. Ammonia	11
1.5. Food types	12
1.5.1. Microalgae	.12
1.5.2. Yeast	15
1.6. Rotifers culture methods	17
1.6. Rotifers culture classifications	18
1.6.1.1. Batch culture	18
1.6.1.2. Semi-continuous culture	19
1.6.1.3. Continuous culture	20
1.6.1.4. Feedback culture	21
1.6.1.5. Ultra-high density culture	22
1.6.2. Stock culture.	23
1.6.3. Mass of rotifers production of algae	25
1.6.4. Mass production of rotifers on algae and yeast	26
1.6.4.1. The daily –tank-transfer method	27
1.6.4.2. Batch culture system (two-day batch culture system)	28
1.6.4.3. Semi-continuous culture (five-day semi-continuous culture system).	28
1.6.5. Mass culture of rotifers on yeast	28

1.6.6. Hi	gh rotifers density rearing	29
1.7. Rot	ifers harvesting	31
1.8. Prod	uction and use of rotifers resting eggs	32
CHAPT	CHAPTER II. MATERIALS AND METHODS	
2.1. Stud	y area	36
2.2. Food	l types	36
2.2.1. Ch	aetoceros sp.	36
2.2.2. Ins	stant algae [®] (Isochrysis sp. and Nannochloropsis sp.)	37
2.2.3. Ye	ast	39
2.3. Expe	erimental rotifers	39
2.4. Expe	2.4. Experimental procedure	
2.5. Mon	2.5. Monitoring of water quality	
2.6. Anal	ytical procedures	43
2.6.1. Es	timation of growth and production rate	43
2.6.2. Nu	stritional quality	44
2.7. Statistical analysis		44
CHAPTER III. RESULTS		
CHAPT	ER IV. DISCUSSION	68
CHAPT	ER V. CONCLUSIONS AND RECOMMENDATIONS	75
REFER	ENCES	78
	List of Tables	
Table	Title	Page
No	2.44.4	No.
1	Some of the research work carried out on the daily production	9
	of rotifers subjected to different salinities and food organisms.	

2	Culture medium used for diatoms	37
3	The concentrations, cell sizes and nutritional profile (% of dry weight from algae) of instant algae [®] used in the experiments.	38
4	Experimental design of the study.	42
5	Production rate (mean No.±sd ml ⁻¹) of rotifers exposed to different feed types and salinities.	48
6	Increments (%) at the end of the culture experiments with rotifers exposed to different feed types and salinities.	50
7	Specific growth rate (SGR % day ⁻¹) at the end of the culture experiments with rotifers exposed to different feed types and salinities.	50
8	Resting eggs production of rotifers (mean No±sd ml ⁻¹) exposed to different feed types and salinities.	51
9	Chemical composition (% Dry matter basis) of rotifers exposed to different feed types and salinities.	54
10	Some fatty Acids of total lipid from rotifers exposed to different feed types and salinities (% of total lipids weight).	55
11	Concentration of elements extracted from dry rotifers samples (mg kg ⁻¹ dry weight) obtained at the end of the culture experiments	56
12	Ammonia concentrations (mean±sd mg l ⁻¹) measured during the culture period of rotifers exposed to different feed types and salinities.	60

13	Nitrite concentrations (mean±sd mg 1-1) measured during the culture period of rotifers exposed to different feed types and salinities.	61
14	Dissolved oxygen concentrations (mg l ⁻¹) measured during the culture period of rotifers exposed to different feed types and salinities.	62
15	pH levels recorded during the culture period of rotifers exposed to different feed types and salinities.	63

List of Figures

Figure	Title	Page
No.		No.
1	Production rate of rotifers (No ml ⁻¹) exposed to different	49
	feed types and salinities	

2	Resting eggs (No ml ⁻¹) produced by rotifers exposed to different feed types and salinities.	52
3	Ammonia concentrations (mg 1 ⁻¹) measured during the culture period of rotifers exposed to different feed types and salinities.	64
4	Nitrite concentrations (mg 1 ⁻¹) measured during the culture period of rotifers exposed to different feed types and salinities	65
5	Dissolved oxygen concentrations (mg l ⁻¹) measured during the culture period of rotifers exposed to different feed types and salinities	66
6	pH levels recorded during the culture period of rotifers exposed to different feed types and salinities.	67

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Abstract

The growth rate and nutritional quality of the S-type rotifers *Brachionus* rotundiformis under four different salinity levels fed three different food types were tested and these resulted in differences in maximum density (production No. ml⁻¹), increment (%) and specific growth rate (SGR % day⁻¹) after 84 hours trial culture period. The maximum production rates were higher in the cultures fed on baker's yeast in all experimental groups. The production rates of rotifers (mean No±sd ml⁻¹) fed baker's yeast at 20, 30, 40, 50 ppt were (±SD)

320.7±3.80, 219.3±19.5, 211.3±3.2 and 204.0±5.3 individuals ml⁻¹, respectively. The lowest production rates were observed in the cultures fed instant algae[®] *Isochrysis sp.* under all salinity levels and the mean production rates recorded at 20, 30, 40, and 50 ppt were 218.3±15.6, 205.0±7.0, 198.0±10.0 and 177.3±27.9 individuals ml⁻¹ respectively. The increments (%) and specific growth rate (SGR % day⁻¹) were significantly higher in the cultures fed on baker's yeast in all experimental groups and were lower in all treatments fed instant algae[®] *Isochrysis sp.*. Resting eggs production during the culture period was positively related to the production rate of rotifers. **The** highest number of resting eggs produced (no. ml⁻¹) was recorded for the rotifers cultures fed baker's yeast at all salinity levels at different intervals. On the other hand, the rotifers fed instant algae[®] *Isochrysis* sp. showed variations in the numbers of resting eggs produced during all intervals. The numbers were observed to decline with time and increasing salinity until it reached the minimum in the 50 ppt cultures.

The study suggested that there is a strong relationship between the food type and culture conditions. Accordingly, protein content and ether extract were found to be higher in all treatments fed baker's yeast under all salinity levels. The lowest protein and ether extract contents were recorded in the cultures fed instant algae. *Isochrysis sp.* Saturated fatty acids (myristic acid C14:0; palmitic acid C16:0; margaric acid C17:0 and stearic acid C18:0), a monounsaturated fatty acid (oleic acid C18:1 ω 9) and one polyunsaturated fatty acid (linoleic acid C18:2 ω 6) were detected.

The results clearly showed that the concentration of excretory products (nitrogenous compounds) was inversely correlated with the density of rotifers per ml under the affection of salinity and food type.

The cultures of rotifers fed backer's yeast at 20 ppt salinity level recorded the maximum ammonia concentration and the minimum concentration of ammonia were measured in the cultures of rotifers fed on chaetoceros sp. at 50 ppt salinity level. However, nitrite concentrations were maximum in the cultures of rotifers fed on *chaetoceros sp.* at 40 ppt salinity level and the minimum concentrations were measured in the cultures of rotifers fed on baker's yeast at salinity level of 50 ppt. Rotifers cultures fed Chaetoceros sp., instant algae® Isochrysis sp. and baker's yeast at 20 ppt salinity level showed relatively higher levels of dissolved oxygen concentrations which were 2.67±0.15, 2.63±0.06, and 2.53±0.12 mg.l-1, respectively. The minimum dissolved oxygen concentrations were recorded in the cultures of rotifers fed on instant algae[®] Isochrysis sp. at 30 ppt salinity level followed by the cultures fed *Chaetoceros* sp. at 50 ppt salinity level and the cultures of rotifers fed instant algae[®] Isochrysis sp. at the same salinity level. The range levels of pH recorded during the experimental period was 7.22-7.78±0.01. This was considered to be within the optimum range for rotifers multiplication.

الخلاصة

تمت دراسة تأثير الملوحة ونوع الغذاء على معدل النمو والقيمة الغذائية للروتفيرات ذات الحجم الصغير من نوع Brachionus rotundiformis تحت أربعة مستويات ملوحة ، Baker's yeast في الألف) وثلاثة أنواع من الغذاء (خميرة الخبز Baker's yeast طحالب الفورية المركزة من نوع Chaetoceros sp.

ايزوكرايسيس.Instant algae $^{ ext{$(1)}}$ ايزوكرايسيس.Instant algae اعدادها ونتج عن ذلك اختلافات في كثافة اعدادها ونسبة زيادتها ومعدل نموها النوعي بعد 84 ساعة فترة تربية. معدلات الإنتاج القصوى كانت أعلى في جميع التجارب التي تمت تغذيتها على خميرة الخبز تحت مستويات الملوحة الأربعة ، 20، 30، 40 و 50 جزء في الألف ، حيث كانت قيمها (± الإنحراف المعياري) 3.8±320.7 ، 219.3 \pm 219.3 ، 19.5 \pm 219.3 و 204 \pm 3.2 خليه /المليمتر، على التوالي وأدنى معدلات تم تسجيلها لجميع التجارب التي تمت تغذيتها على الطحالب الفورية المركزة من نوع $\pm 208.15.6 \pm 218.3$: قيمها $\pm 218.3 \pm 201.80$ 0.7، 198 \pm 10 و $177.3 \pm 27.9 \pm 27.5$ خلية/ المليمتر على التوالى. نسبة الزيادة (%)ومعدل النمو النوعي (%/ اليوم) كانت أعلى بشكل معنوي في جميع التجارب التي تمت تغذيتها على خميرة الخبز تحت مستويات الملوحة الأربعة. إنتاج البيض الساكن (خلية/ المليمتر) resting eggs في جميع المجموعات التجريبية كان ذو علاقة بمعدل الإنتاج لكل مجموعة. وعليه فإن أعداده كانت اكبر في جميع التجارب التي تمت تغذيتها على خميرة الخبز تحت مستويات الملوحة الأربعة. المجموعات التي تمت تغذيتها على الطحالب الفورية المركزة من نوع ايزوكرايسيس أظهرت إختلافات في أعداد البيض المنتج تحت جميع مستويات الملوحة. ولوحظ ان أعداد البيض الساكن تتناقص بزيادة الملوحة و الفترة الزمنية للزراعة حتى وصل الى أقل أعداده في جميع المجموعات تحت مستويات الملوحة 50 جزء في الألف.

الدراسة الحالية إقترحت وجود علاقة قوية بين الروتفيرات، نوع الغذاء وظروف التربية وتبعاً لذلك فإن نسبة محتوى البروتين الخام و المستخلص الإثيري كانت أعلى فى الروتفيرات التي تمت تغذيتها على خميرة الخبر تحت جميع مستويات الملوحة وأقل نسب للبروتين الخام و المستخلص الإثيري تم تسجيلها فى الروتفيرات التي تمت تغذيتها على الطحالب الفورية المركزة من نوع ايزوكرايسيس تحت جميع مستويات الملوحة. الأحماض الدهنية المشبعة (حمض المايريستك 0:14:0 وحمض البالميتك 0:16:0 حمض المارقاريك 0:17:0 وحمض الستريك الدهنية المشبعة (حمض الأوليك 9 و18:1) وأحد الأحماض الدهنية المتعددة غير المشبعة (حمض اللينوليك 06 (C18:2)) تم الكشف عنها في جميع عينات الروتفيرات لكل المجموعات التجريبة.

أظهرت التجارب بوضوح أن تركيزات المواد الإخراجية (المواد النيتروجينية) الناتجة من الروتيفيرات داخل وسط التربية تحت تأثير الملوحة ونوع الغذاء المستخدم ذات تأثير عكسي على كثافة أعداد الروتفيرات في المليمتر المجموعات التجريبية التي تمت تغذيتها على خميرة الخبز تحت مستوى الملوحة 20 جزء في الألف سجلت أعلى قياس لتركيزات للأمونيا وأقل تركيزات له تم قياسها للمجموعات التي تمت تغذيتها على الطحالب من الكيتوسيروس تحت مستوى الملوحة 50 جزء في الألف. ومن ناحية أخرى فإن أعلى تركيزات النتريت تم قياسها للمجموعات التي تمت تغذيتها على طحالب الكيتوسيروس تحت مستوى الملوحة 40 جزء في الألف وأقل تركيزات له تم قياسها للمجموعات التي تمت تغذيتها على خميرة الخبز تحت مستوى الملوحة 50 جزء في الألف. المجموعات التي تمت تغذيتها على طحالب الكيتوسيروس ، الطحالب الفورية المركزة من نوع ايزوكرايسيس و خميرة الخبز تحت مستوى الملوحة 20 جزء في الألف أظهرت إرتفاعاً نسبياً في مستويات تركيزات الأكسجين الذائب والتي كانت: 0.12 ± 2.63 و أقل تركيزات 0.06 ± 2.63 هاجرام/الليتر على التوالى. و أقل تركيزات لمستويات الأكسجين الذائب تم تسجيلها للمجموعات التي تمت تغذيتها على الطحالب الفورية المركزة من نوع ايزوكر ايسيس تحت مستوى الملوحة 30 جزء في الألف تليها المجموعات التي تمت تغذيتها على طحالب الكيتوسيروس تحت مستوى الملوحة 50 جزء في الألف والمجموعات التي تمت تغذيتها على الطحالب الفورية المركزة من نوع ايزوكرايسيس تحت نفس مستوى الملوحة. الأس الهيدروجيني pH خلال فترة التجارب تتراوح بين 7.22- 7.7 ± 0.00 والذي بعتبر ضمن المدى الأمثل لتكاثر الروتفبرات

INTRODUCTION

Most of the marine finfish larvae with aquaculture potential have very limited yolk reserves and at start of exogenous feeding most of the larvae were observed to die in the past. It was later recognized that the problem was due to

the fact that newly hatched larvae are usually very small, extremely fragile, and generally not physiologically fully developed. For example, their small size (i.e. small mouth size), the uncompleted development of their perception organs (i.e. eyes, chemoreceptor) and digestive system, are limiting factors in proper feed selection and use during the early first-feeding or start-feeding period (Fountaine and Revera, 1980; Reitan et al., 1994; Bromage and Roberts, 1995; Sanoamuang et al., 2001; Arimoro 2006). To overcome this problem, various types of food, including a number of zooplankton, protozoa, larvae of marine finfish, minced fish...etc., were tried without success (Fountaine and Revera, 1980). This situation continued until the rotifers were recognized as the most suitable live food starter (Lubzens, 1987). The success of rotifers as a culture organisms are due to their planktonic nature, nutritional quality, tolerance to wide range of environmental conditions, high reproduction rate (0.7-1.4 offspring/female/day). Moreover, their small size (130-320µm), slow swimming velocity and tendency to stay suspended in the water column make them a suitable prey for fish larvae that have just reabsorbed their yolk sac (Hirata, 1979, 1980; James et al., 1983; Lubzens, 1987; Dhert et al., 1995; Dhert, 1996; Fengqi, 1996). On the other hand, the filter-feeding nature of rotifers allows inclusion in body tissues of specific nutrients (bioencapsulation) essential for fish larvae such as essential fatty acids, vitamins and antibiotics (Watanabe et al., 1983; Watanabe, 1991; Theilacker and Kimball, 1984; Lubzens, 1987). The most widely used species is Brachionus plicatilis, a cosmopolitan inhabitant of inland saline and coastal brackish waters (Fukusho, 1989). However, for use in aquaculture, a simple classification is used which is based on two different morphotypes, namely B. rotundiformis or small rotifers (S-type) with a lorica length ranging from 100 to 210 µm (average 160 µm) and B. plicatilis or large rotifers (L-type) with a lorica

length ranging from 130 to 340 μ m (average 239 μ m) (Fielder et al., 2000; Hagiwara et al., 2007).

Basically, several algal species have been used to feed seawater rotifers species. Other alternative food types such as yeast, waste water from food industry and live stock, minced fish and a number of species of zooplankton, protozoa and larvae of marine finfish have been used for rotifers mass culture (Klekot and Klimowicz, 1981; Takano, 1995; Samra et al., 2001). Baker's yeast was first used by Hirata and Mori (1967) as food for the saline water species *B. plicatilis*. Since then a number of investigators have used bakers' yeast as food for this species and rotifers grown in this way have also been nutritionally enriched (Fernandez-Reiriz and Labarta 1996, Lie et al., 1997).

Beside the effect of the food type, the nutritional quality of rotifers is also very much affected by the biotic factors of the seawater. The rotifer *B. plicatilis* (*rotundiformis*) is a euryhaline species and can withstand a wide salinity range from 1 to 97 ppt. (Fengqi, 1996). However, optimal reproduction can only take place at salinities below 35 ppt (Lubzens, 1987).

Objectives of the study

Despite the abundant information on the culture of rotifers, the combined effect of food type and salinity still remain an area of interest for further investigation. Therefore, this study was designed to study the production rates and nutritional quality of S-type rotifers, *B. rotundiformis*, fed two different species of microalgae (*Chaetoceros* sp. and concentrated instant algae[®] *Isochrysis* sp.), and baker's yeast under four salinity levels.